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RESEARCH STUDIES OF HOUSEHOLD SEWAGE DISPOSAL SYSTEMS

James B. Coulter

Federal Security Agency
Cincinnati, Ohio

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RESEARCH STUDIES OF HOUSEHOLD SEWAGE DISPOSAL SYSTEMS*

James B. Coulter
Sr. Asst. Sanitary Engineer

Federal Security Agency SANITA
Public Health Service
Environmental Health Center
Cincinnati, Ohio

It is a distinct pleasure to meet and discuss the subject of household sewage disposal systems with persons who are actively engaged in the manufacturing of septic tanks. Not only am I privileged to pass first-hand information concerning our studies on to people who can put it to good use, but I am also privileged to hear first-hand the problems as you actually encounter them in the field. First-hand information of problems in the field is of prime importance to us; because we attempt to keep our studies geared to the solution of those problems as they come to our attention. As some of you may know, these studies are under the joint sponsorship of the Housing and Home Finance Agency and the Public Health Service. The studies are being conducted at Cincinnati by the Public Health Service; however, field teams have operated in ten different sections of the country, inspecting over 300 septic tank systems in the field.

Part I of a series of reports entitled, "Studies on Household Sewage Disposal Systems," has been published and may be obtained, upon request, from the Environmental Health Center or the Government Printing Office. This report, which is in the form of a progress report, covers the work done during the period, November, 1946 to June, 1948. A second report in this series, Part II, covering the six-month period, January to July, 1949, is in press and should be available for distribution soon.

*For presentation at the Conference with the Illinois Association of Precast Concrete Septic Tank Manufacturers at Springfield, Illinois on December 4, 1951.

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As you are familiar with the general features of the usual septic tank soil absorption system, I shall not take time for elemental description. I want to emphasize, however, that the septic tank is but one part of this over-all system of disposal. Its functions are significant only from the standpoint of its behavior in relation to the other parts of the system. Quite often you may hear remarks on the performance of this or that septic tank without qualifying explanation of the disposal of the waste beyond the tank. There is danger in attaching significance to such claims, which is more easily understood when one reflects that a septic tank discharging to a ditch or gravel formation may appear to operate satisfactorily for many years; whereas, the same tank in a system of disposal to soil absorption might fail miserably in a short time under similar circumstances of attention, or more preferably, the lack of attention.

In my discussion tonight, I will treat the studies under four general headings: first, Field Studies; second, Laboratory Septic Tank Experiments; third, Special Experiments; and fourth, Laboratory and Field Soil Studies.

Field investigations supplement our laboratory investigations and also provide valuable information which cannot be gained under laboratory conditions. For instance, we can compare the performance and patterns of behavior of tanks in the laboratory using municipal sewage. However, the use of municipal sewage does not enable us to observe the rate or pattern of scum and sludge accumulation which we would expect in the field under normal household circumstances. Then, too, the magnitude of individual variations can be measured only in the field. We have attempted to select a representative sample for our field studies, and have applied statistical methods to that sample so that we feel that we have a good measurement of the variation to be expected and that our data is applicable to general cases.

During the period, February, 1947, to July, 1948, 300 single household septic tanks in normal operation, located in nine areas over the country, were examined by two-man engineer-laborer teams. Sludge and scum accumulations were measured and the family history and living habits of each installation were taken. Using as a basis for comparison the amount of sludge and scum per capita retained in a tank after a given period of service, a comparison was made concerning the effect of capacity upon the performance of the tank. It was found that in tanks in the 125 to 175 gallon per capita liquid capacity group, unit accumulations approximated the average accumulation for all tanks of all capacities. Tanks with per capita capacity smaller than 125 to 175 gallons accumulated less sludge and scum while larger per capita capacity tanks tended to accumulate more solids in the same period of time. From the study of scum and sludge accumulation data as presented in the Part I report, it appears that capacity is a very important factor in the accumulation of solids. This is an important factor when we consider that solids which are not retained in the tank must pass on to the soil where irreparable damage could be done.

A statistical study of the sludge and scum accumulation data gives us some formulas and other information which can be valuable in the rational design of a septic tank. In order to arrive at an economical balanced design for a septic tank, it is necessary to know at least three things; first, the rate of sludge and scum accumulation and the magnitude of normal variation expected to be encountered in that rate; second, the maximum amount of sludge or scum which a tank will store and still function at an acceptable level of solids removal; and third, a cleaning period or interval of time between servicing which will give the most economical balance between first cost and maintenance cost.

The average accumulation trends presented in Part I of the report were made on a per person basis. While it is possible, and in one respect more accurate, to do this where the person loading history is available, we find that the final application to design always comes back to bridging the gap between a residence of known history and a proposed residence for which the future occupancy is indeterminate. The only thing we know concerning a new house is its physical size which in turn may be expressed in the number of rooms or bedrooms that the house contains. As our original survey gave us the data concerning house size, we have re-examined our sludge and scum accumulation figures on the basis of the number of bedrooms in the house which the septic tank serves. Using this data we were able to derive a regression line formula for the rate of accumulation for both sludge and scum per bedroom against time in operation. However, if we are to put a tank in the ground which will operate successfully for most homes, it must be designed from accumulation curves which envelop most of the cases. The rate of accumulation represented by the formulas which I am about to present will be exceeded in only one case out of 20 actually encountered in the field.

For sludge accumulation these equations are:

Two-bedroom home: $Y = 12.45 + X$

Three-bedroom home: $Y = 11.80 + .48X$

Where Y equals the cubic feet of sludge accumulation per bedroom and X is equal to the time in years of service.

For scum accumulation these equations are:

Two-bedroom home: $Z = 5.05 + .56X$

Three-bedroom home: $Z = 7.18 + .14X$

Where Z is equal to the accumulation of scum per bedroom and X is equal to the time in service in years.

From the average curves presented in Part I of the report on these studies, it was demonstrated that three-fourths of the scum accumulated below the water line and therefore occupied liquid capacity of the tank. The equations which I have just given you are for total scum accumulation including the scum accumulating above the water line.

Concerning the maximum amount of sludge which a septic tank will store, there is some indication inthe field data that the sludge storage capacity of a tank may be influenced by the penetration of the outlet device, as well as by the total liquid capacity of the tank. An average trend was observed in which sludge levels tended to reach a point approximately one foot below the bottom of the outlet device as a maximum. We have defined this distance between the top of the sludge and the bottom of the outlet device as clear space. If the concept of a minimum clear space for all tanks is true, then this fact gives us the maximum sludge storage capacity for any tank. It may be well to emphasize again at this point that the sludge storage capacity of the tank must be evaluated in terms of the performance of the tank. In other words, where the effluent is emptied to a ditch or water course, it might be possible, through a process of gradation and separation, to fill the tank with sludge solids to, and perhaps above, the bottom of the outlet device. However, in effluent going to subsoil disposal, the pores in some soils would probably be tightly clogged with fine suspended particles before that amount of sludge could accumulate. We have conducted a laboratory experiment to shed further light on this concept of clear space. We filled a 500-gallon tank with sludge to its full capacity. We then fed raw sewage

to the tank in the normal laboratory manner to observe at what level the sludge would stabilize itself and no longer be affected by the scouring action of sewage passing through the tank. We found that during the cold winter months this level was established at a point approximately one-third of a foot below the bottom of the baffle. However, during the warmer months of summer, scouring action carried the sludge level to approximately one foot below the bottom of the outlet baffle. This experiment was in reverse to the processes as they naturally occur in the field, and therefore, is of limited value. It does, however, clearly demonstrate that the sludge level is affected by a scouring action, and will normally reach a point of equilibrium somewhere below the bottom of the outlet device. As with all of the factors concerned with biological activity, there seems to be a random variation in the clear space which develops in various tanks; however, from a review of our findings to date, an assumption of about one foot for clear space seems reasonable.

Using the accumulation formulas presented and making the assumption of the one foot minimum clear space, we have solved two of the factors of design, namely, the rate of sludge and scum accumulation and the maximum amount of sludge which a tank will accumulate. The third, the cleaning period, or intervals of time between cleanings, is a factor which may be assigned within limits arbitrarily for use in the sludge and scum accumulation formula depending somewhat upon economic circumstances prevailing.

It may be well to discuss at this time the matter of tank cleaning. To the best of my knowledge, there is no way to avoid the physical removal of accumulated solids from a septic tank if efficient operation is to be maintained and if the all-important water absorption characteristics of the soil are to be protected. I am inclined to feel, however, that the setting

of some blanket cleaning period, whether it be three or five or some other number of years, does not answer this problem. As you may have gathered from my previous remarks, there is considerable variation between individual installations in the rate at which they accumulate sludge and scum. In order to safeguard the high-accumulation installations, a short cleaning period would severely penalize those systems which could safely run several times as long without cleaning. A logical solution would depend on periodic inspections of individual tanks by the home owner or others so that cleaning could be accomplished as necessary. We have attempted to develop some means whereby a sludge level might be gaged, within practical limits, with a simple home-made device. A weighted string and a roughened stick did not appear to work at the laboratory. However, a long stick wrapped with a piece of towelling and left in contact with the tank contents several minutes showed promise.

This group might be interested in our experiences concerning the freezing aspects of household sewage disposal systems. We have conducted a survey of the literature including the septic tank recommendations of 11 northern states, several case histories, unpublished information from Canadian investigators and a poll of northern plumbers. Based on this information it appears that a carefully constructed shallow household system with gravel-filled tile lines will rarely freeze if kept in continuous operation. There does, however, appear to be a need for the insulation of pipes under driveways and under other surfaces usually cleared of snow. These statements apply only to household systems in actual operation. County school systems have been known to freeze. Investigation of county school systems freezing in Calhoun County, Michigan in 1948 revealed some unusual

conditions compared with those usually encountered in household systems. There were longer periods of daily and weekly idleness of the system and no hot water was being used in the schools where freezing occurred. There were no reports of household system freeze-ups at that time in the same vicinity.

Turning now to the study of septic tanks and related appurtenances under laboratory conditions, I wish to point out that many of the individual experiments which we undertake could lead to studies lasting a lifetime. However, as our project is one of practical as well as basic research, it becomes necessary for us to discontinue a study as soon as we are certain that a firm trend has been established. For this reason many questions of deep interest must go unanswered or be deferred to a later date when more pressing problems have been solved. I would also like to emphasize again that the septic tank and the soil disposal field supplement each other as integral parts of the same system. One physical characteristic necessary for the proper performance of the distribution field is the percolation quality of the soil or the ability of liquids to move through that soil. To date, no rapid practical means of improving or restoring soil percolation is known. When the ability of the soil to absorb water is lost, it becomes necessary to dig up and relocate the distribution field. Therefore, it becomes one of the prime functions of the septic tank to protect the original percolation rate of the soil. This function may be accomplished by trapping and holding a large proportion of the suspended solids, and by subjecting raw sewage to digestive processes in the septic tank. Our laboratory soil studies have shown, during a three-month period of dosing, that the rate of soil clogging was proportional to the amount of suspended solids in the effluent. Therefore, in evaluating the performance of septic tanks in the laboratory, we use the efficiency of suspended solids removal as our main criterion.

The septic tanks under observation in our laboratory are full-scale tanks and are dosed with fresh raw sewage collected from a combined sewer serving a nearby residential district. This raw sewage is pumped to an elevated dosing tank from which all tanks are dosed with equal amounts of sewage at approximately two-hour intervals during the working day. Each day eight feeds are made, starting at seven o'clockin the morning and ending at ten o'clock at night, seven days a week. The quantity of each individual feed varies during the day to conform to a water consumption pattern obtained by studying the metered water rates for the homes of personnel of the Environmental Health Center. The rate of raw sewage flow to the septic tank is manually regulated at ten gallons per minute. Effluent is collected in individual receivers after each feed and sampled for a larger composite sample which is used in solids determinations. Routinely, solids content, temperature and pH determinations are made on both the effluent and on the raw sewage. When required, special determinations include B.O.D., dissolved oxygen, sulfides, grease, gas analysis and bacteriological examinations.

In the first phase of the study, 18 full-size septic tanks were operated under parallel conditions for periods up to a year. Included were five single-compartment tanks of approximately 500 gallons capacity but of different shapes. Vertical and horizontal circular, rectangular, and oval-shaped tanks were represented. Under identical circumstances the suspended solids removals for all five tanks for the entire year ranged between 59 and 65 per cent. In other words, for the same capacity, variation in shape of the single-compartment tank had no appreciable effect on efficiency. The variation in depth was too small to be indicative of behavior under any radical departure from four feet, although it appeared from this study that

a small variation, say half a foot, would make little difference. Depth studies are being conducted which I will discuss shortly.

In the first phase of our study it was also possible to gain an insight into the effect of tank capacity on performance. A very large single-compartment tank with a total capacity of 2,060 gallons performed at an 80 per cent suspended solids removal level compared with the 60 per cent for single-compartment tanks. This difference in performance is more evident when it is considered from the viewpoint of solids in the effluent. Assume, for instance, a sewage with 100 ppm of suspended solids. Approximately 40 ppm of those solids would pass through a single compartment tank of 500 gallons capacity while only 20 ppm would be contained in the effluent from the larger tank. The larger tank would, therefore, cut the solids load going to the soil by one-half.

Tanks of capacity smaller than 500 gallons have been investigated also. While these tanks started with reasonably good results, they appeared to reach their small sludge storage capacity quickly with an accompanying dropping off of efficiency. Small capacity tanks seemed to respond to temperature changes in an exaggerated manner. A seasonal cycle correlated with temperature changes was evident in a tank of 123 gallons capacity. Efficiency was fairly high during cold weather with a rapid accumulation of sludge. The quality of the effluent deteriorated rapidly with the onset of warm temperatures of summer, and, for a period of ten weeks, the effluent contained more solids than the sewage going into the tank. During this ten-week period of poor performance the winter's accumulation of sludge was lost. Performance during the remainder of summer and fall was erratic and generally poor, but improved considerably with the onset of cold winter

temperatures. Identical results were obtained when the experiment was duplicated by starting a tank in the summer.

In the early phase of the study it was shown that an apparent advantage could be gained through compartmentation of experimental septic tanks. Two tanks, a 553-gallon two-compartment and a 673-gallon four-compartment tank, both of the round vertical type, produced effluent which was considerably better than that from any other tanks in the same capacity range. In fact, the four-compartment tank operated at a slightly higher level of performance than the 2,060-gallon single-chamber tank; while the two-compartment tank operated on the same level of performance as the large single-chamber tank.

A recent study has been completed in which three rectangular tanks, each of approximately 500 gallons total liquid capacity and four-foot liquid depth, were divided into a one-, a two-, and a three-compartment tank and put into operation under laboratory conditions. During the two-year period, January, 1949 to January, 1951, the two-compartment tank operated at a suspended solids removal of 70 per cent, while the single and the three-compartment tank were at approximately 60 per cent. These figures are based only on the raw sewage added to the tank and do not include periodic sludge additions. By January, 1951, the tanks had apparently reached their maximum sludge storage capacity and went into a state of failure, which marked the end of the experiment during the summer of 1951. The maximum sludge storage capacity of the two-compartment tank was in the neighborhood of 37 cubic feet while that of the single-compartment and three-compartment tank was in the neighborhood of 30 cubic feet. A round vertical type tank of two compartments, two feet in diameter, having a total liquid capacity of

500 gallons and liquid depth of approximately 10 feet in each compartment, gave results comparable to those of a single-compartment 500-gallon tank but did not approach the performance of two-compartment 500-gallon tanks of more conventional depth. Small capacity compartmented tanks registered good performance when first started but quickly reached their sludge storage capacity, with attendant failure. A review of our findings to date indicates that compartmentation can be used to good advantage. The problems of compartment size and compartment proportions are yet to be solved.

Some exploratory work has been done on tank inlet, outlet and inter-compartment appurtenances. For the sake of obtaining some quick information, these were run on the basis of detention time using uranin dye as a tracer. Ultimately this work must be verified using suspended solids removal as the criterion to test promising arrangements. Dye tests indicated that there was essentially no difference in the retention time obtained from similar tanks using a tee inlet, a baffled inlet or a plain type inlet; however, there was an indication of a slightly better flow pattern for the tee inlet followed by the baffled inlet and the plain sewer inlet, in that order. Two rectangular tanks of three compartments each were tested; one equipped with vented inverted U's between compartments and the other, first with a four-inch horizontal tank-width slot and later, a four-inch diameter hole located at the center of the partition, both the slot and hole submerged 12 inches to the top of the opening. Results indicated that the slotted partitions gave the same experimental detention time as a tee-fitted single-compartment tank of equal capacity, and only one-half the detention time of the inverted U-equipped three-compartment tank. When the slot opening was constricted to a four-inch diameter hole at the center of the tank and at the same depth,

the detention period lengthened but did not reach that of the inverted U-equipped tank. One experiment on outlets has been performed in which no essential difference was found in the suspended solids removals from two tanks identical except that one was operated with a tee outlet and the other with a baffled tank-width weir. At present, two 500-gallon tanks of four foot water depth identical in every respect except that one tank is equipped with an outlet tee having penetration below the water line of 13 inches and the other tank having a similar tee with outlet penetration of 17 inches, are being operated under parallel conditions. The experiment is still in progress, but has almost reached completion. Since midway in the experiment, when the sludge levels became relatively high, the tank with the shallower outlet penetration has shown a tendency to accumulate and hold more sludge than the tank with the deeper outlet penetration.

The depth factor has been a topic of some interest and, as you may know, the Joint Committee on Rural Sanitation and many of the states have recommended a minimum liquid depth of four feet. As our earlier work did not cover this factor specifically, four rectangular tanks of equal capacity, 500 gallons, but varying water depth, have been under observation for approximately two years. The four tanks have length to width ratios of 2 to 1, and the liquid depths are $28\frac{1}{2}$, 36, 48 and 64 inches respectively. At intervals throughout the experiment sludge was added to the depth tanks in order to study removal efficiencies at various sludge levels and to determine, if possible, the maximum volume of sludge which could be stored in each tank before failure occurred. The original scheme was to establish a pattern of behavior at a low sludge level. An equal quantity of sludge would then be added to each tank and the pattern of behavior with this new sludge volume would then be observed. Practical difficulty was encountered,

however, in keeping the volume of sludge in each of the tanks equal. The heavy sludge additions caused a disturbance in the tanks which extended over a period of weeks and the severity of which seemed to vary from tank to tank in a random manner. During the periods of poor performance following the sludge additions, sludge would be lost from the tank in varying amounts, and in a few cases the amount of sludge lost equaled the amount of sludge added. This erratic behavior makes it difficult to forecast results at this early date. However, a few general statements may be made which must be considered tentative. For some unknown reason, and apparently some reason other than the depth factor, the 48-inch tank went into a state of failure early in the experiment at a low sludge level. Therefore, for the time being at least, the behavior of this tank will not be considered in the depth study. Of the remaining three tanks, statistical studies show that the difference in performance between the tanks was not significant prior to their failure from excessive sludge accumulations. The 36-inch deep tank went into a state of permanent failure when the clear space reached approximately 1.0 feet. In spite of subsequent sludge additions the sludge level in this tank has tended to return to the one foot clear space. In the deepest tank, the 64-inch tank, sludge storage capacity was apparently reached when the clear space reached approximately $1\frac{1}{2}$ feet. However, the tank recovered from its apparent state of failure and is now giving relatively good performance at a clear space approaching one foot. The shallowest tank, $28\frac{1}{2}$ inches, showed indications of failing midway in the experiment when the clear space had been reduced to approximately 9/10 of a foot. However, in the latter phase of the experiment this tank has registered good performance in spite of a clear space as small as 3/10 of a foot. The

experiment is being continued to determine if this better over-all performance of the shallower tank is one of the biological chance behaviors with which we have to contend in these studies or whether there is an actual advantage to be gained from shallower depths and greater surface areas. It is hoped to determine if good performance can continue in this shallowest tank in the face of the greatly reduced clear space, and if not, what the true clear space and individual sludge storage capacity of this tank should be.

Before closing the discussion of laboratory septic tank studies, we have observed a general pattern of behavior which may be of interest to you, and which I hope will make you more critical of experimental studies of this type. Based on the removal of suspended solids, we have observed a seasonal type of behavior correlated with temperature changes. As a general rule, during winter and spring months, efficiencies are high and sludge accumulates at a relatively rapid rate. With late spring or early summer, accelerated digestion in raw or semi-raw solids accumulated during the winter cause a disturbance in the tank. The severity depends upon the number of factors, including temperature, capacity, compartmentation, and the amount of sludge in the tank. During the period of disturbance there is usually a loss of solids followed by a slow recovery in the performance curve characterized by erratic behavior during the summer months. Efficiencies again recover in the fall and winter and the cycle repeats itself. Seasonal variation is not as pronounced in tanks of large capacity as it is in those of small capacity. Neither is it as pronounced in compartmented tanks of proper capacity and design, leading to a more stable year-around performance. However, in the compartmented tank sludge does move downstream from compartment to compartment during the period of early summer upset. These observations lead us

to the conclusion that to properly evaluate the performance of a septic tank we must observe performance during all periods of the year, and we must be cautious in accepting results from short-time experiments, especially from experiments run under winter conditions or other conditions which would promote a slow rate of digestion in the tank.

By popular demand from various agencies in the field, we have conducted a multitude of special investigations, some of which I will describe briefly. These experiments will be described fully in subsequent reports. In the meantime, more detailed information on specific subjects may be obtained by addressing your inquiry to the Officer in Charge, of the Environmental Health Center.

Some investigation of the behavior of a septic tank receiving ground garbage has been made in the laboratory. During a seven-month period of operation, a garbage-sewage-fed tank discharged less suspended matter than a tank to which sewage only was fed. However, during the next three months of the operation, the comparative performance of the garbage-sewage-fed tank fell off considerably. It is thought that the greater amount of solids stored in the garbage tank over the cooler winter months resulted in a greater increase in digestion activity at the higher spring and summer temperatures near the end of the run, which in turn caused the garbage tank to discharge more solids. Concerning digestion of the garbage solids, it is interesting that the pH's for both tanks were about the same, ranging around 7.3 and 7.5. The ratio of effluent volatile suspended solids to suspended solids for the garbage-sewage tank tended to be higher than that of the sewage fed tank. This higher ratio may indicate a comparatively greater proportion of raw or partly digested matter, as compared with the effluent from the sewage fed

tank. If so, this may explain in part at least the soil clogging behavior of the garbage-sewage-fed tank effluent as compared with that of the sewage fed tank.

There is definite evidence that septic tanks receiving ground garbage may require larger absorption fields. Dosing of sewage-garbage effluent to soil cores caused a more rapid rate of clogging than did the sewage-only effluent, both on a basis of equal length of time of dosing, and on a basis of an equal amount of suspended solids added. In order to maintain the same rate as cores receiving normal effluent, laboratory data indicates that the area of cores receiving ground garbage effluents would have to be increased by 20 to 35 per cent. I would like to emphasize, however, that this cannot be considered a final figure, as the results have been obtained on only four soil types and under laboratory dosing conditions. To develop a comprehensive figure will require careful analysis of data gathered in the field.

From April through July, 1951, 39 systems were examined in Duval County, Florida, near Jacksonville, with the primary purpose of obtaining data for comparing the behavior of systems with and without garbage grinders. From preliminary examinations of sludge and scum accumulations data, indications are that there was, at least, an average increase of 50 per cent in sludge-plus-scum accumulation in the septic tanks receiving ground garbage as compared with that in tanks not receiving garbage. The greater part of the increase was in the scum.

A limited preliminary examination of absorption field data indicates that there was more organic matter in soil samples from systems receiving ground garbage than in samples from non-garbage systems. Percolation rates on soil cores taken from systems receiving ground garbage tended to be lower

than the rates in cores taken from non-garbage systems. The sandy nature of the soil encountered in this area tends to minimize these differences.

For the time being, we feel that the 50 per cent increase in tank capacity recommended by the Joint Committee, F. H. A., and others, to compensate for ground garbage in the household waste, is a reasonable allowance. If I were designing a system for myself, on the basis of our present knowledge, I would also increase the area of the soil absorption field by 50 per cent to provide for the inclusion of ground garbage wastes.

Frequently we receive inquiries about the application of chemical or biological compounds to clean or condition septic tanks. While we cannot attempt to test every commercial compound on the market, we have conducted experiments with some of the known active agents of these compounds. A few statements concerning our experiments with caustic soda may be helpful. In one of these cases the addition of 25 pounds of sodium hydroxide to a 455-gallon septic tank under laboratory observation caused an immediate rise in the effluent pH to 12.3 from its original value ranging about 7.3. For five successive days, the pH remained above 11.0. Digestion in the tank was dormant for a period of twenty-three weeks during which time sludge accumulated at a rapid rate. Following the twenty-third week after the addition of caustic soda, digestion re-started, accompanied by rapid gasification which produced a serious disturbance in the tank. Large quantities of suspended solids were discharged from the tank for a period of four weeks following the re-start of digestion. It is known that some of the so-called "septic tank cleaners" contain sodium hydroxide as the active agent.

Dramatic results were obtained when soil cores were dosed with effluent containing sodium hydroxide. At a pH of 10 and above soil clogging

occurred almost immediately, accompanied by a destruction of soil structure. It will be recalled that the effluent from a 455-gallon tank registered a pH above 11.0 for five days after being dosed with 25 pounds of sodium hydroxide. A recommended dose of cleaner is 25 pounds for a 250-gallon tank. Yeast has been investigated as a possible seed material or starter for sewage digestion, and was found to have no merit. In my opinion a well-designed and properly maintained septic tank needs no auxiliary props. This statement does not preclude the use of ripe septic tank sludge as a starter.

Many localities have become interested in the effects of discharging zeolite water softener regeneration wastes to the septic tank system. As you know, these wastes contain a high concentration of mixed salts of sodium, calcium and magnesium. Early bottle tests indicated that a 1.2 per cent solution of mixed salts inhibited digestion; and that this effect was reduced by mixing and flushing. A 2.4 per cent solution of mixed salts in a full-sized tank failed to dilute in the bottom layers even under the influence of periodic sewage feeds. An experiment was conducted in which, in addition to the regular feeds of raw sewage, once each week mixed salts were introduced into a 455-gallon tank in a manner designed to simulate the discharge of waste from a water softener. It was demonstrated that chloride concentrations built up to a high ranging from 1.0 to 1.2 per cent near the bottom of the tank during cold weather; however, the tank, for all practical purposes, purged itself of salt with the advent of warm weather. In spite of high salt concentrations in the sludge layer, digestion seemed to proceed well at all times during this experiment. Further investigation revealed that sludge in the tank had become acclimated to salt environment; and was inhibited little, if any, by a salt concentration of one per cent; while at the same concentration

a normal sludge was strongly inhibited. Caution should be exercised in applying these results to a new installation or to one which has been cleaned and returned to service without seed sludge.

Soil cores were also dosed with the effluent from the tank receiving the weekly salt additions. No appreciable difference in soil clogging between the salt effluent and a normal effluent was noted. In fact, there was some evidence that solids in the salt effluent caused less clogging than those in the normal effluent. There was, however, some damage to soil structure in the cores dosed with salt effluent. In that stability of soil structure is an index of sustained soil permeability, such damage may be more important from the long time viewpoint than the short time percolation behavior noted above. Field examinations of soils in residential systems receiving softener wastes will be made at the first opportunity to determine what the long range effect is.

Turning now to the soil studies, the conventional septic tank system depends upon the soil distribution field for the ultimate disposal of the bulk of sewage it receives. The magnitude of the task we impose on the soil can be appreciated when we consider that the average rainfall in Illinois is approximately 37 inches annually; and the amount of effluent applied annually to a disposal field, based on current design, ranges from 240 inches for tight soils to 1,100 inches for porous soils. In some cases in the field over 2,000 inches were being applied.

A problem of immediate concern is that of devising methods whereby the soil absorption area required for any specific system may be quickly and accurately determined. A number of factors are concerned such as: clogging characteristics of septic tank effluent, volume of waste to be

disposed of, climate, and most important, the absorption characteristics of the particular soil to be used.

In the 1920's Henry Ryon, working in New York State, developed a percolation test which has proved to be a useful tool. He developed an empirical relationship between the rate at which a soil would absorb clear water and the rate at which it would absorb septic tank effluent. Ryon's test and empirical relationship, with perhaps some slight modification, is apparently the basis for most of our present day soil absorption field recommendations advocated by the various control agencies.

We have investigated the Ryon test and are in a position to suggest some modifications which we believe to be improvements.

First, we would substitute a four-inch auger hole for the foot square dug hole now being used. Comparative tests employing a foot square dug hole, an eight-inch auger hole, and a four-inch auger hole in soils representing a wide range of rates and absorption characteristics have shown conclusively that, in the same soil, there is no significant difference in the percolation rate as measured by any of these hole sizes.

Second, we suggest a more complete saturation of the soil before measuring the percolation rate. This is particularly true of clayey type soils subject to swelling as saturation proceeds. In experimental studies test holes were filled with water to a 12-inch depth. Measurements were made every 10 to 15 minutes for four hours. The holes were then filled and allowed to soak overnight and the test was then repeated over a four hour period the next day. That more complete saturation can be of practical concern is apparent when we consider the results of one of these experiments. This experiment was conducted in a Rossmoyne soil, and if the rate were calculated by averaging the first day's results and referring to the Joint Committee on

Rural Sanitation table, an absorption area of 208 square feet would be required, and the site would be acceptable. If, however, the rate were taken over the last 30 minutes of the second day, the site would not be acceptable. This latter case agrees with the performance of the soil under operating conditions. In this soil not one of a number of systems investigated was considered satisfactory. One system, about five years old, containing 300 square feet of absorption area and receiving toilet waste only from one adult and two children was found to be completely flooded with serious surface seepage occurring. This inspection was made in August, temperatures were high, vegetation over the field was lush and conditions in general were most favorable for successful operation.

Third, we suggest that the rate at the end of the test rather than the initial or some average rate be used. In making a percolation test a large decrease may take place during the early part of the test. The magnitude of this decrease depends upon prior moisture conditions and characteristics of the soil involved. The decrease will be more pronounced if the test is started in a dry soil, and is likely to be more pronounced in a clay-type soil than in a sandy-type soil. A plot of a typical percolation rate would demonstrate that the rates tend to approach a minimum asymptote as saturation proceeds. The lower rates obtained near the end of the test are undoubtedly more representative of soil behavior under tile field conditions.

Another suggestion, although strictly speaking not a modification of the Ryon test, is to make enough replicate tests to cover inherent variabilities in the soil encountered. The time and labor saved by using smaller test holes could be profitably employed in making these replicates.

Soil clogging is a study towards which we are directing much of our attention. The empirical relationship evolved by Ryon was developed under the limited soil conditions of New York and under sewage characteristics prevailing at that time. Such complicating factors as ground garbage, automatic washers, detergents, softener wastes and so on had not made their appearance. To develop a new empirical relationship to include those factors would entail a tremendous amount of costly and time consuming field work. We are, however, investigating individual factors in the laboratory to determine their effect on soil clogging from which adjustment of the relationship may be made.

It would be logical to consider the causes of soil clogging under three general headings: physical, chemical and biological. Septic tank effluent can contribute to all three types of clogging. Actually, from preliminary studies it appears that biological activity does not cause soil clogging under effluent dosing conditions, but instead tends to reduce clogging caused by other factors. Laboratory soil cores packed with a variety of soils and dosed with effluent over a three-month period clogged in proportion to the amount of suspended solids in the effluent. After a few weeks of dosing, biological activity appeared to reduce the rate of clogging. Furthermore, a disinfected effluent applied to cores showed a more rapid rate of clogging than normal effluent applied to identical cores. Apparently digestion taking place in the soil results in a net decrease in soil clogging.

Another factor to be considered is the relative soil clogging effect of detergents as compared to soap. To date, four independent experiments,

three in the laboratory using hand packed cores and one at a field site using auger holes, have been completed along this line of endeavor. Briefly, these four experiments and the preliminary results obtained from them are:

(1) Clear water solutions of detergent, which did not have the complicating physical clogging influence of solid particles, caused less clogging than similar solutions of soap. After several weeks of treatment, the detergent solutions actually caused an increase in percolation rates.

(2) Increased concentrations of either soap or detergent in septic tank effluent caused greater clogging of soil cores than did effluent without additions. There was no significant difference in clogging between the soap and detergent treatments.

(3) In field hole studies, clear water solutions of detergent caused less clogging than comparable solutions of soap.

(4) Home laundry waste water containing either soap or detergent caused greater soil core clogging than did whole effluent. Again, as in (2), there was no significant difference in clogging between the soap and detergent solutions.

Further study is planned, but before instigating new experiments the data obtained thus far is being studied to determine if there are hidden factors which would explain the variable nature of results obtained thus far.

In closing, I should like to emphasize two thoughts which should be kept in mind in dealing with "septic tank systems." The first is that the septic tank is not a disposal system of itself, but is an important unit

of a process in which the objective is the disposal of waste liquid into the ground. Soil, for waste disposal purposes, is a sensitive medium, not only sensitive to the heavy liquid loadings we place on it, but susceptible, also, to damage from abnormal changes in the waste being applied to it. We should keep this in mind, not only in considering septic tank design and operating factors, but also in connection with servicing procedures. The second thought is that while the development of factual information is of fundamental importance, it will fall short of its purpose if it is not applied to the design, installation, operation and servicing of each individual installation.